Global Hydrology Resource Center

Data User Guide

GOES-R PLT Fly's Eye GLM Simulator (FEGS)

Introduction

The GOES-R PLT Fly's Eye GLM Simulator (FEGS) dataset consists of lightning flash, lightning pulse, and radiance data collected by the FEGS flown aboard a NASA ER-2 high-altitude aircraft during the GOES-R Post Launch Test (PLT) airborne science field campaign. The GOES-R PLT airborne science field campaign took place between March 21 and May 17, 2017 in support of the post-launch product validation of the Advanced Baseline Imager (ABI) and the Geostationary Lightning Mapper (GLM). These data files are available in ASCII format with browse imagery available in PNG format.

Notice:
This dataset is not continuous as flights did not occur every day. FEGS flash and pulse data are unavailable for the following flight dates: March 23 and 28, April 6, 11 and 13, and May 7, 2017.

Citation

Quick, Mason G., Hugh Christian and Richard J. Blakeslee. 2019. GOES-R PLT Fly's Eye GLM Simulator (FEGS) [indicate subset used]. Dataset available online from the NASA EOSDIS Global Hydrology Resource Center Distributed Active Archive Center, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/GOESRPLT/FEGS/DATA101

Keywords:

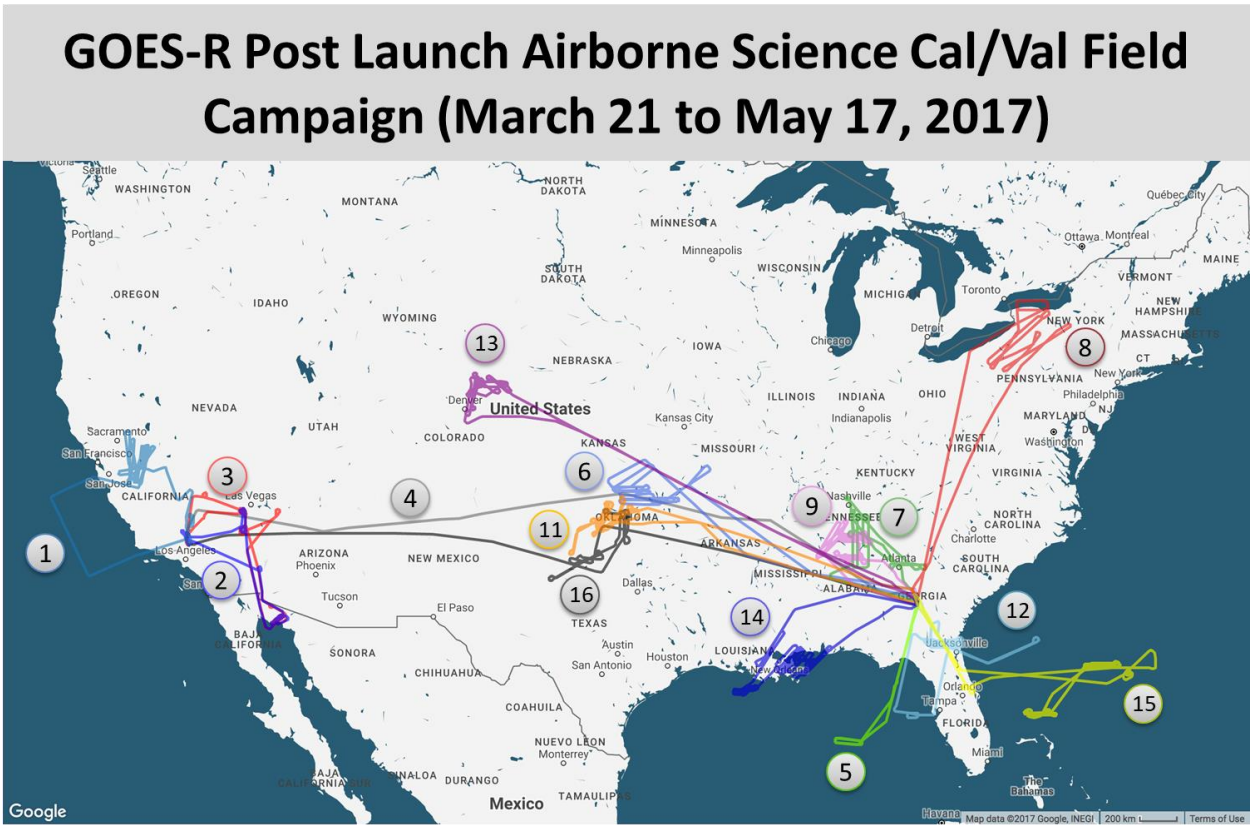
NASA, GHRC, CONUS, lightning, GOES-R, PLT, GLM, FEGS, ER-2, radiometer

Campaign

The Geostationary Operational Environmental Satellite-R (GOES-R) series is a four-satellite program including GOES-R, GOES-S, GOES-T, and GOES-U. The GOES-R Series Program is a collaborative development and acquisition effort between the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) to develop, launch and operate the satellites. The first satellite in the GOES-R series, GOES-R, launched on November 19, 2016 and became GOES-16 when it

reached geostationary orbit. GOES-16 replaced GOES-13 as NOAA's operational GOES East satellite at 75.2 degrees west longitude on December 18, 2017. GOES-16 observes North and South America, as well as the Atlantic Ocean all the way to the west coast of Africa. GOES-16 provides high spatial and temporal resolution imagery of the Earth using its Advanced Baseline Imager (ABI). GOES-16's Geostationary Lightning Mapper (GLM) is the first operational lightning mapper flown in geostationary orbit. GOES-16 also includes four other scientific instruments for monitoring space weather and the Sun.

The GOES-R Post Launch Test (PLT) airborne science field campaign took place between March 21 and May 17, 2017 in support of the post-launch validation of NOAA's new generation of geostationary Earth observing instruments: ABI and GLM (Figure 1). The validation effort included targeted data collections from a NASA ER-2 high-altitude aircraft integrated with nine payloads (both passive and active instruments) coordinated with ground based and low earth-orbit referenced data from several operational and research satellite missions. Sixteen ER-2 aircraft validation missions, totaling 105.1 mission flight hours, were conducted over ideal Earth validation targets, such as deserts and oceans, thunderstorms, active wildfires, and an expansive set of cloud and moisture phenomenology. Dedicated ABI 30-second mesoscale (MESO) imagery collections were conducted concurrent with the ER-2 high-altitude aircraft based sensors during each GLM mission. The GOES-R PLT field campaign provided critical reference data and new insights into the performance NOAA's new generation of geostationary Earth observing instrument products. More information about the GOES-R PLT field campaign is available at https://www.goes-r.gov/mission/fieldCampaignBegins.html and https://www.goes-r.gov/multimedia/events/goes16FieldCampaign.html.



*Flight #10 - April 27, 2017 - Huntsville, AL not shown due to aircraft navigation not reporting

Figure 1: GOES-R PLT airborne science field campaign

(Image Source: Frank Padula)

Instrument Description

FEGS is an airborne radiometer system designed to provide calibration and validation measurements for GLM from high altitude aircraft. It consists of a 5 x 5 array of radiometers each with a narrow passband filter to isolate the 777.4 nm neutral oxygen emission triplet radiated by lightning. The radiometers measure the optical radiance emitted by lightning that is transmitted through the cloud top with a temporal resolution of 10 µs. When integrated on the NASA ER-2 aircraft, the FEGS array with its 90° field-of-view observes a cloud top area nearly equal to a single GLM pixel (8-14 km from nadir to edge of the field of view). This design allows FEGS to determine the temporal and spatial variation of light that contributes to a GLM event detection.

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Data Characteristics

The GOES-R PLT FEGS dataset contains data files in ASCII format and browse imagery files in PNG format at a Level 1A processing level. More information about the NASA data processing levels are available on the EOSDIS Data Processing Levels webpage. Table 1 shows the characteristics of this dataset.

Table 1: Data Characteristics

Characteristic	Description
Platform	NASA ER-2 aircraft
Instrument	Fly's Eye GLM Simulator (FEGS)
Spatial Coverage	N: 43.572 , S: 26.449, E: -72.202, W: -124.624 (Continental United States)
Spatial Resolution	point
Temporal Coverage	March 21, 2017 to May 17, 2017
Temporal Resolution	Daily -< Weekly
Sampling Frequency	10 microseconds
Parameter	Lightning pulse, lightning flash, radiance
Version	1
Processing Level	1A

File Naming Convention

The GOES-R PLT FEGS data files are available at a Level 1A processing level in ASCII format with browse imagery available in PNG format. These data and browse files have the following file naming convention.

Data files: goesr_plt_FEGS_YYYYMMDD_[Flash|Pulse|MedianBG]_[v2|vK2].txt
Browse files: goesr_plt_FEGS_YYYYMMDD_MedianBG.png

Table 2: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month

DD	Two-digit day
Flash|Pulse|MedianBG	Flash: Flash Level Data Pulse: Pulse Level Data MedianBG: 1 second median background data
v2|vK2	Data version number
.txt	ASCII format
.png	Portable Network Graphics format

Data Format and Parameters

FEGS Pulse Level Data, both Version 2 ('v2') and Version K2 ('vK2'), provide timing, location, measured power, energy and temporal characteristics of the optical pulses identified in the FEGS data set. The background radiance was estimated and subtracted from the optical time series and statistically large pulses were identified. The 'v2' data (Table 3) gives all of the pulse information for all of the individual FEGS detectors, while in 'vK2' data (Table 4), the signal from all 25 radiometers in the main FEGS array are summed. FEGS Flash Level Data Version 2 ('v2') is derived from the FEGS Pulse Level Data. Flashes are clustered using a 330 ms time window mimicking the GLM clustering criterion (Table 5). FEGS 1 Second Median Background data files ('MedianBG') list the median bit value for one second periods of data and for each radiometer channel (Table 6). FEGS browse imagery files in PNG format contain time plots of 1 second median bit values and aircraft navigation (latitude, longitude, altitude and roll angle).

Table 3: Data columns in GOES-R PLT FEGS Pulse Level Data Version 2 files.

Column	Parameter	Description
1	Pulse ID	Pulse ID tag. PulseID =1 is the first pulse detected during the flight.
2	Data Channel Number	Data Channel Number for the radiometer that detected the pulse.
3	Year	Microsecond precision UTC timestamp for the beginning of the 1 second data period that contains the identified optical pulse.
4	Month	
5	Day	
6	Hour	
7	Minute	
8	Second.subsecond	
9	GPS second	GPS timestamp of the 1 second data period that contains the identified optical pulse. The subsecond information from column 6 should be added to this for subsecond accuracy.
10	Latitude	3D GPS location and Roll angle of the ER-2 at the time of the pulse. *
11	Longitude	
12	Altitude	

13	Roll Angle	
14	Pulse Start Index	Start and stop index of the pulse within the 1 second data period. The index identifies the sample number of the digital signal that a pulse begins and ends on. FEGS sample rate is 100 kHz, and sample period is 10 μs. Thus the beginning time of each pulse is found by adding the time stamp listed in columns 3-9 to the start index multiplied by 10 μs.
15	Pulse Stop Index	
16	Pulse Peak Radiance [W/m2 Sr]	Calibrated peak radiance measured for the detected pulse for the specified radiometer.
17	Pulse Duration [ms]	Duration of time that the lightning signal was identified above the background level
18	Pulse 10-90 % Rise Time [ms]	Time period for the optical pulse to increase from 10% of the peak value to 90% of the peak value on the initial rise to peak.
19	Pulse 10-10 % Width [ms]	Duration of time the pulse radiance was larger than 10% of the peak value.
20	Pulse 50-50 % Width [ms]	Full Width at Half Maximum of the pulse, and indicates the duration of time that the pulse radiance was larger than 50% of the peak value.
21	Pulse Radiant Energy [J/m2 Sr]	Radiant energy measured by integrating the radiance over the duration of the pulse for the specified radiometer.
22	Pulse complexity	A parameter to quantify the number of radiance peaks superimposed upon one another during the identified pulse. For low S/N ratios, this parameter greatly overestimates the actual number of peaks. Currently this parameter is not trustworthy.
23	Signal-to-Noise Ratio	Ratio of the Pulse Peak Radiance to the Standard Deviation of the Background Radiance.

24	Mean Background Radiance [W/m2 Sr]	An estimate of the background radiance at the time of the identified pulse.
25	Maximum Pixel Number illuminated by the pulse	--
26	FOV Latitude 1	GPS coordinates of a 4 point polygon that roughly outlines the FEGS FOV at the time of the pulse. This spatial footprint assumes a cloud top height of 13 km which was typical for storms observed during the GOES-R Validation ER2 flight campaign.
27	FOV Longitude 1	
28	FOV latitude 2	
29	FOV Longitude 2	
30	FOV Latitude 3	
31	FOV Longitude 3	
32	FOV Latitude 4	
33	FOV Longitude 4	

*Note: Roll angles greater than about 5 degrees indicate that the ER2 was in a turn, and the footprint of the FEGS FOV at cloud top will be highly skewed. Pulses observed during a turn should be analyzed with caution.

Table 4: Data columns in GOES-R PLT FEGS Pulse Level Data Version K2 files.

Column	Parameter	Description
1	Pulse ID	Pulse ID tag. PulseID =1 is the first pulse detected during the flight.
2	Data Channel Number	Data Channel Number for the radiometer that detected the pulse. For data version "K" the channel number is always 0 indicating the pulse was detected on the summed array waveform.
3	GPS second for the start of the pulse	Microsecond precision GPS-second and GPS-subsecond for the beginning and end of the pulse.
4	Subsecond for the start of the pulse	
5	GPS second for the end of the pulse	
6	Subsecond for the end of the pulse	
7	Latitude	3D GPS location and Roll angle of the ER2 at the time of the pulse.*
8	Longitude	
9	Altitude	
10	Roll angle	
11	Pulse Peak Radiance [W/m2 Sr]	Calibrated peak radiance measured for the detected pulse. The radiance is assumed to be uniform over the 25 pixels in the main FEGS array.
12	Pulse Radiant Energy [J/m2 Sr]	Radiant energy measured by integrating the radiance over the duration of the pulse. The radiance is assumed to be uniform of the 25 pixels in the main FEGS

		array.
13	Pulse 10-90 % Rise Time [ms]	Time period for the optical pulse to increase from 10% of the peak value to 90% of the peak value on the initial rise to peak.
14	Pulse 10-10 % Width [ms]	Duration of time the pulse radiance was larger than 10% of the peak value.
15	Pulse 50-50 % Width [ms]	Full Width at Half Maximum of the pulse, and indicates the duration of time that the pulse radiance was larger than 50% of the peak value.
16	Pulse Complexity	A parameter included to quantify the number of radiance peaks superimposed upon one another during the identified pulse. For low S/N ratios, this parameter greatly overestimates the actual number of peaks. Currently this parameter is not trustworthy.
17	Signal-to-Noise Ratio	Ratio of the Pulse Peak Radiance to the Standard Deviation of the Background Radiance.
18	Mean Background Radiance [W/m2 Sr]	An estimate of the background radiance at the time of the identified pulse.
19	Maximum Pixel Number illuminated by the pulse	--
20	FOV Latitude 1	GPS coordinates of a 4 point polygon that roughly outlines the FEGS FOV at the time of the pulse. This spatial footprint assumes a cloud top height of 13 km which was typical for storms observed during the GOES-R Validation ER2 flight campaign.
21	FOV Longitude 1	
22	FOV latitude 2	
23	FOV Longitude 2	
24	FOV Latitude 3	
25	FOV Longitude 3	
26	FOV Latitude 4	
27	FOV Longitude 4	

*Note:Roll angles greater than about 5 degrees indicate that the ER2 was in a turn, and the footprint of the FEGS FOV at cloud top will be highly skewed. Pulses observed during a turn should be analyzed with caution.

Table 5: Data columns in GOES-R PLT FEGS Flash Level Data Version 2 files.

Column	Parameter	Description
1	Flash ID	Flash ID tag. FlashID =1 is the first flash detected during the flight.

2	GPS second for the start of the flash	GPS time stamp for the beginning and end of the flash.
3	Subsecond for the start of the flash	
4	GPS second for the end of the flash	
5	Subsecond for the end of the flash	
6	Latitude of the ER-2	3D location and roll angle of the ER-2 at the time of the flash.*
7	Longitude of the ER-2	
8	Altitude of the ER-2	
9	Roll angle of the ER-2	
10	Peak Radiance of the flash [W/m2 Sr]	Peak radiance of the most luminous optical pulse in the flash. Radiance is calculated by summing the signal from the 25 radiometers in the main FEGS array and dividing by 25 to get the average radiance.
11	Integrated Radiant Energy of the Flash [J/m2 Sr]	Sum of radiant energy of all pulses in the flash.
12	Mean Background Radiance during the Flash [W/m2 Sr]	Estimated background radiance (non-lightning radiance) averaged over the 25 radiometers in the main FEGS array.
13	Maximum Pixel Number illuminated during the flash	--
14	FOV Latitude 1	GPS coordinates of a 4 point polygon that roughly outlines the FEGS FOV at the time of the flash. This spatial footprint assumes a cloud top height of 13 km which was typical for storms observed during the GOES-R Validation ER2 flight campaign.
15	FOV Longitude 1	
16	FOV latitude 2	
17	FOV Longitude 2	
18	FOV Latitude 3	
19	FOV Longitude 3	
20	FOV Latitude 4	
21	FOV Longitude 4	

*Note: Roll angles greater than about 5 degrees indicate that the ER2 was in a turn, and the footprint of the FEGS FOV at cloud top will be highly skewed. Flashes observed during a turn should be analyzed with caution.

Table 6: Data columns in GOES-PLT FEGS radiance data files.

Column	Parameter	Description
1	year	GPS time stamp for the beginning of the one second period
2	month	
3	day	
4	hour	
5	min	
6	sec	
7	subsec	

8	lat	GPS location of the ER-2 at the specified time
9	lon	
10	alt	
11-40	ch1, ch2, ch3, ….., ch30	Median of the bit values recorded during the one second period beginning at the specified time for each radiometer channel

Software

No software is required to view these ASCII data files and PDF browse imagery.

Known Issues or Missing Data

This dataset is not continuous as flights did not occur every day. Flash and pulse data are unavailable for the following flight dates: March 23 and 28, April 6, 11 and 13, and May 7, 2017.

During the ER-2 flights the FEGS GPS antennae would occasionally lose its satellite link which resulted in erroneous time/location readings in three data files:
goesr_plt_FEGS_20170514_MedianBG.txt
goesr_plt_FEGS_20170323_MedianBG.txt
goesr_plt_FEGS_20170517_MedianBG.txt
These files, however, contain legitimate radiometer data that could be utilized if desired.

References

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https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160014729.pdf

Related Data

All datasets from GOES-R PLT field campaign can be considered related to this GRIP LIP dataset. Other GOES-R PLT campaign data can be located using the GHRC HyDRO 2.0 search tool, by entering the term 'GOES-R PLT'.

Contact Information

To order these data or for further information, please contact:

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